Table 2
Summary of Grain Size Analysis of Vibracore Samples

Number	Approx. Depth ft. NGVD	Mean (mm) M_{mm}	Mean (phi) M_{phi}	Sorting S_{phi}	Variance S^2_{phi}	% Silt <230 Sieve	% > 2mm	% > 1 mm
BIVC-02-01								
BIVC-02-01 #1	-3.8	0.26	1.94	0.86	0.74	1.20	1.36	3.05
BIVC-02-01 #2	-4.8	0.21	2.24	0.51	0.26	1.59	0.03	0.00
BIVC-02-01 #3	-8.8	0.24	2.04	0.82	0.67	1.62	1.27	2.94
BIVC-02-01A #1	-11.1	0.64	0.63	2.32	5.38	0.91	18.96	26.33
BIVC-02-01B #1	-20.5	0.64	0.64	1.56	2.43	0.57	11.30	27.27
BIVC-02-02								
BIVC-02-02 #1	-5.0	0.28	1.83	0.88	0.77	1.19	1.38	3.97
BIVC-02-02 #2	-7.3	0.24	2.08	0.56	0.31	1.33	0.21	0.41
BIVC-02-02 #3	-9.0	0.37	1.43	1.22	1.49	1.21	4.33	8.72
BIVC-02-02 #4	-12.0	0.25	2.02	0.55	0.30	1.24	0.00	0.12
BIVC-02-03								
BIVC-02-03 #1	-5.3	0.34	1.56	0.88	0.77	1.03	1.18	3.81
BIVC-02-03 #2	-8.8	0.31	1.69	0.98	0.96	1.36	1.98	5.18
BIVC-02-03 #3	-10.8	1.34	-0.43	2.22	4.93	0.73	30.24	48.99
BIVC-02-03 #4	-12.3	0.45	1.16	0.93	0.86	0.80	3.18	7.32
BIVC-02-03A #1	-13.5	0.21	2.27	0.49	0.24	1.59	0.54	0.68
BIVC-02-04								
BIVC-02-04 #1	-14.3	0.26	1.94	0.84	0.71	1.21	0.48	1.73
BIVC-02-04 #2	-16.3	0.38	1.41	1.52	2.31	1.28	5.26	13.20
BIVC-02-04A #1	-17.5	0.27	1.91	0.90	0.81	1.11	0.00	1.09
BIVC-02-04A #2	-19.2	0.52	0.93	1.64	2.69	0.96	10.32	19.69
BIVC-02-04B #1	-20.7	0.87	0.19	2.12	4.49	0.93	21.97	33.59
BIVC-02-05								
BIVC-02-05 #1	-24.8	0.15	2.74	0.57	0.32	1.88	0.18	0.55
BIVC-02-05 #2	-28.1	0.65	0.61	1.55	2.40	1.20	10.11	19.38
Average all samples		0.42	1.47	1.27	1.61	1.19	5.92	10.86
Avg. of samples above -17.5		0.38	1.61	1.16	1.35	1.21	4.40	7.97

One of the alternatives under consideration would use a portion of the material removed from the inlet to reposition the channel midway between Bogue Banks and Bear Island to nourish the 23,831 feet of beach included in Phase 3 of the Emerald Isle beach nourishment project. Accordingly, an analysis was performed to determine the compatibility of the inlet material with the native beach material. When beach fill material is placed on the upper portion of the beach, it undergoes a certain degree of sorting by wave action that tends to move discrete grains sizes to quasi-equilibrium positions on the active beach profile. In general, the coarser fraction of the borrow material will remain on the upper or higher energy portion of the profile while the finer grained material will be transported to deeper depths. Compatibility analyses between beach fill material and native beach material is carried out using composite characteristics that include samples of the native beach out to some depth of closure of the fill with the pre-project profile. Based on the wave climate in the Bogue Banks area and the configuration of the existing beach profile, the depth of closure appears to be approximately 20 feet below MLW (-21.5 feet NGVD). The Corps of Engineers, as part of an island wide Federal storm damage reduction feasibility study, collected samples of the native material for the entire length of the island from the base of the dune seaward to the 24-foot depth contour with samples being collected at 2-foot depth intervals across the profile. Four of the profiles sampled by the Corps of Engineers are located within Phase 3 of the Emerald Isle beach nourishment project. The samples collected from these four profiles out to a depth of -20 feet NGVD were used to compute the characteristics of the native beach material within the Phase 3 beach nourishment area. Table 3 provides a summary the characteristics of the samples collected at discrete points on the profile and the characteristics of the composite native material for these four profiles.

Table 3
Characteristics of the Native Beach Material
Phase 3 – Emerald Isle Beach Nourishment Project
(Corps of Engineers Profile Stations 962+84.91, 1033+59.23, 103+90.23, 1174+03.3)

Sample Location	Average Shell Content (% by weight)	Mean (mm)	Mean (phi units)	Standard Deviation (phi units)
Berm Crest	2.20	0.24	2.05	0.459
MHW	5.16	0.25	2.0	0.617
MSL	16.44	0.39	1.36	1.085
MLW	27.87	0.48	1.07	1.404
-3	4.87	0.22	2.19	0.611
-4	2.46	0.21	2.25	0.524
-6	1.50	0.18	2.49	0.277
-8	1.38	0.16	2.60	0.258
-10	1.63	0.15	2.70	0.332
-12	2.17	0.16	2.68	0.369
-14	1.61	0.17	2.52	0.442
-16	2.59	0.17	2.52	0.442
-18	2.59	0.16	2.60	0.563
-20	2.70	0.16	2.68	0.369
Composite	5.37	0.22	2.26	0.790

The compatibility of borrow material for use as beach fill is determined by a numerical method that compares the mean grain size and sorting characteristics of the borrow material to the mean and sorting characteristics of the native beach material. The results of that comparison yields a factor known as the overfill ratio (R_a) which is an indication of the number of cubic yards of borrow material needed to result in 1 cubic yard of sorted beach fill material. If the borrow material is completely compatible with the native material, R_a will be equal to 1.0 and the net volume of material needed will equal the gross or borrow area volume. R_a greater than 1.0 means that more material is needed from the borrow area to yield 1 cubic yard of sorted material on the beach. The overfill factor for the inlet material was determined to be 1.015. Adjusting the overfill factor for the amount of sand in the inlet material (98.75%) results in a total overfill factor of 1.03.

The overfill factors for the Bogue Inlet material is highly compatible with the native beach material with total sorting and winnowing losses expected to be five percent or less. This is not particularly surprising as the ebb tide delta is composed primarily of material derived from the adjacent beaches. Apart from the compatibility of the grain sizes, when material is removed from a borrow area and deposited on a beach, there are inherent differences in the volume of material removed from the borrow area compared to the volume that can be measured on the beach. Much of this difference is due to measurement error and a factor commonly referred to as shrinkage. Based on past experience, the difference between borrow area volume and the volume of sediment retained on the beach generally ranges from 10 to 20 percent. Since the material in Bogue Inlet is highly compatible with the native beach material, the total overfill factor would be around 1.15.

4.2.3 Depleted Natural Resources

According to the North Carolina Division of Coastal Management (NCDCM), Bogue Inlet is located within several NCDCM Areas of Environmental Concern. Under the NCDCM Coastal Area Management Act (CAMA), permits are necessary for development type projects proposing work in any Areas of Environmental Concern (AEC) established by the Coastal Resources Commission. An AEC includes areas of natural importance such as 1) estuarine and ocean systems, 2) ocean hazard system, 3) public water supplies, 4) natural and cultural resource areas. Under CAMA, the proposed work cannot cause significant damage to one or more of the historic, cultural, scientific, environmental or scenic values or natural systems identified in any of the AECs listed. In addition, significant cumulative effects cannot result from a development project. (NCDENR, 2003)

The Natural Heritage Program has designated several Significant Natural Heritage Areas within the project area. Significant Natural Heritage Areas of Bogue Inlet are located on or around Huggins and Dudley Islands, West End Beach on Emerald Isle, and Hammocks Beach State Park. Significant Natural Heritage Areas include exemplary natural communities (elements of natural diversity) and various endangered plants and animals. Some examples of exemplary natural communities in the area include brackish marsh, maritime swamp forest, and salt marsh. There are several threatened and endangered animals in the area of Bogue Inlet which are further described in the Biological Assessment (Appendix G).

4.3 VEGETATION

The following sections identify the various types of vegetative habitats found within the Permit Area. These habitats were field verified by CZR, Inc. in September 2003 (see Appendix I).

4.3.1 Maritime Hammocks

Forested maritime hammocks are typically isolated and flooded by storm surges. These forested systems are dominated by live oak (*Quercus virginiana*), loblolly pine (*Pinus taeda*), and red cedar trees with an understory of shrub thicket which can such species as include swamp bay (*Persea palustris*) and sweetbay (*Magnolia virginiana*). The dominant wind direct and influence of salt spray is usually evidenced by the sculpted vegetation. (USC, 2002; Texas Cooperative Research Unit, 2002)

Utilizing the digital aerial image collected on June 30, 2003, forested maritime hammocks were identified in the Permit Area mainly on the northeast end of Bear Island and on the south side of Dudley Island, totaling approximately 50.5 acres. See Appendix D – Biotic Community Map. Additional maritime communities found along Bear Island include maritime wet grasslands, maritime scrub, and maritime evergreen forests (S. Regier, pers. comm.).

The nearest upland hardwood forest is approximately 46 feet east outside the Permit Area on Emerald Isle just east of the Coast Guard Channel. The closest upland mixed forest is 0 feet from the outside of the Permit Area perimeter located at the northwest end of Emerald Isle just east of the Coast Guard Channel. The Permit Area perimeter is 0 feet away from the nearest upland shrub area located on South Dudley Island.

The closest wetland hardwood region is 0 feet from the permit perimeter in Emerald Isle lying just east of the coast guard channel. The nearest wetland mixed forest is 0 feet away from the inside of the permit perimeter on the east side of the Western Channel. The perimeter of the permit region near south Dudley Island is located 0 feet from the closest wetland shrub area.

4.3.2 Beach and Dune Communities

High temperatures, strong winds, and varying wet and dry conditions typical of a dune environment provide unique conditions for plant species with specific adaptations. These specific adaptations include plant species that grow extensive root systems, allowing for prolific growth in unconsolidated beach sand; fleshy leaved plants that provide water storage, limiting the possibility of desiccation.

Beach and foredune environments found in the Permit Area are located on the oceanfront shorelines of both Emerald Isle and Bear Island, as well as the inlet side of Dudley Island. Bogue Banks spit contains an extensive beach and foredune system on the east side of the inlet, providing shelter to other ecosystems in the spit. Island No. 2 also contains a supratidal system of unconsolidated sands and cobbles. Sparse vegetation is found on this ephemeral island. A total of 269.8 acres of beach and dune environments were identified from the June 30, 2003 aerial.

The perimeter of the permit area is located 0 feet from the nearest dune habitat, located inside and outside the permit area along the shoreline of Bear Island. The northeastern end of the Permit Area perimeter is 0 feet from the closest unvegetated sand area. The unvegetated sand areas are located inside and outside the perimeter area on the east side of Dudley Island and the northwest side of Emerald Isle.

Perennial grasses are the primary stabilizers of frontal dune systems along the beach and dune communities of the Atlantic coasts, including the islands that surround Bogue Inlet. North Carolina is located in a vegetation transition zone, between American beach grass (*Ammophila breviligulata*) to the north, and sea oats (*Uniola paniculata*) to the south. These grasses inhabit the front of most dune systems along the Atlantic and can be seen along the dunes of Bogue Banks, Bear Island, and Dudley Island.

Based on the pre-construction mapping, conducted by CZR, Inc., of terrestrial fringing communities around Bogue Inlet, dune grass communities were found to occur primarily on well drained dune systems inland of the beach at Emerald Isle, and on older dune systems along Bear Island where vegetation cover ranges from sparse to fairly dense. Dune grass communities were mapped along Dudley Island with dominant species including sea oats (*Uniola paniculata*), saltmeadow cordgrass (*Spartina patens*), and other grasses. Soils of this community were mapped as Bohicket silty clay loam; identified as a very poorly drained soil. However, conditions indicate that the primary dunes of Dudley Island are an excessively drained soil.

4.3.3 Salt Marsh Communities

Salt marsh communities can be found along 4,500 miles of oceanfront shoreline throughout the sounds, creeks and rivers of North Carolina (NCCF, 2003). The relatively low velocity and flat, poorly drained topographic areas found along the North Carolina coastline have provided for the extensive development of these wetlands. These systems are extremely important for filtering water, providing storage during flood events, supplying food and providing habitat for many species.

The North Carolina Coastal Resource Commission has characterized estuarine systems as an Area of Environmental Concern and identified as “sensitive and productive coastal lands and waters where uncontrolled development might cause irreversible loss of property, public health and the natural environment”. (NCDENR, 2003)

There are four kinds of coastal marsh habitats found in North Carolina: low marsh, high marsh, brackish marsh, and freshwater marshes. Coastal estuarine marsh environments of the Permit Area are located in the western end of Bogue Sound, Dudley Island, and the estuarine system north of Bear Island. The North Carolina Coastal Resource Commission defines coastal wetlands as “any marsh in the 20 coastal counties that regularly or irregularly floods by lunar or wind tides, and that includes one or more of the 10 plant species” identified by CAMA (NCDENR, 2003).

The boundaries of marsh vegetation communities were mapped digitally through visual interpretation of multispectral aerial photography for the Permit and Survey Areas. Marsh communities were classified as low marsh, dominated by smooth cordgrass (*Spartina alterniflora*) or high marsh, dominated by saltmeadow cordgrass (*Spartina patens*). Along with identifying high and low marsh, fringing terrestrial communities were classified as wetland or non-wetland as well as by general vegetation type. Habitat mapping in the Permit Area was conducted by field investigations via boat access in the nearby channels. Verification of the wetland/non-wetland status of communities was determined on foot.

In Bogue Sound, most of the marsh systems are adjacent to disposal islands and appear to be more abundant along the east and west ends of the Sound than in the center of Bogue Sound. In addition to the 808 acres of salt and brackish marsh identified in Bogue Sound by the U.S. Fish and Wildlife Service, 339 acres of scrub-shrub wetlands were identified using aerial photography by the North Carolina Division of Coastal Management. (USFWS, 2002)

Coastal marsh environments of the project area are located in the western end of Bogue Sound, Dudley Island, and the estuarine system north of Bear Island. These marshes are regularly and irregularly flooded lands where plants species such as salt marsh cordgrasses (*Spartina alterniflora* and *S. patens*), glasswort (*Salicornia* spp.), salt grass (*Distichlis spicata*), and sea lavender (*Limonium carolinanum*) may be found. Approximately 808 acres of saltwater and brackish marsh were delineated by the U.S. Fish and Wildlife, and approximately 339 acres were identified by the North Carolina Division of Coastal Management in Bogue Sound (USFWS, 2002).

Fringing terrestrial communities were be classified as wetland or non-wetland as well as by general vegetation type (scrub-shrub, pine forest, hardwood forest, mixed forest, dune grasses, and unvegetated sand). Habitat mapping in the permit area will be field investigated via boat access in nearby channels. Field verification of the wetland/non-wetland status of communities will be performed and dominant plant species in each community will be noted. Once available, this information will be provided in future project documents.

The project effects on vegetative conditions will be most pronounced during active vegetative growth and development periods. Therefore, observations of these effects will be better identified at the end of the growing season in September/October. Pre-construction monitoring to collect baseline conditions was conducted at the end of the growing season September 2003. Annual salt marsh monitoring will continue for three-years post-construction in September/October of each year. Results of the September 2003 monitoring are provided in Appendix I. Due to the timing of the receipt of the lab results, a full analysis of these were results were not calculated. Further interpretation of the organic analysis will be included in the next EIS submission.

<u>High Salt Marsh</u>
Cowardin (1979) classifies high marsh as an estuarine intertidal emergent wetland or palustrine, emergent wetland. High salt marsh environments are irregularly flooded lands where plant species such as saltmeadow cordgrass (*Spartina patens*), glasswort (*Salicornia* spp.), salt (or spike) grass (*Distichlis spicata*), and sea lavender (*Limonium spp.*) may be found. Saltmeadow cordgrass grows at the seaward edge of the high marsh, just above the high water line, providing habitat for a variety of waterfowl and songbirds, as well as other types of wildlife indigenous to the area.

Based on the habitat mapping and field verifications, high salt marsh areas were found to be in an irregularly flooded transitional zone. These areas were found mostly between low marsh and shrub-scrub communities throughout the Project and Permit area of Bogue Inlet. Isolated areas typical of this habitat were also found in several inter-dunal swales or low depressions throughout Bear Island. Vegetation of this community is characteristic of transitional intertidal areas and areas with a high water table in which saltmeadow cordgrass (*Spartina patens*) is the dominant vascular plant. However, sea-oxeye (*Borrichia frutescens*), salt grass (*Distichlis* *spicata*), rushes (*Fimbristylis* spp.), and shrub species such as marsh elder (*Iva frutescens*) and silverling (*Baccharis halimifolia*) coexist. Soils of this community are mapped as Carteret sand and Bohicket silty clay loam.

The closest high marsh area is located 0 feet from the perimeter of the Permit Area. The high marsh is located north inside the Permit Area on the east side of the Western Channel.

Low Salt Marsh

Low salt marsh environments are regularly flooded with the tides and are characterized by organic mats with salt marsh (smooth) cordgrass (*Spartina alterniflora*) as the dominant vegetative species. Smooth cordgrass thrives in low marsh habitats where conditions in the soil are anoxic and where the average water table is 10.2 cm (4 inches) above ground level. This plant is found dominating the salt marsh system between mid- and high tide levels. The upper or inland boundary of this plant is limited by *Spartina patens* on the seaward side of the high marsh.

The ground-truthing and mapping of marsh habitats and fringing terrestrial communities (scrub-shrub, pine forest, hardwood forest, mixed forest, dune grasses, and unvegetated sand) in September 2003 revealed that low marsh was the most extensive of all biotic communities mapped within the Survey and Permit Area. This community is restricted to the intertidal zone in which smooth cordgrass (*Spartina alterniflora*) is the predominant vascular plant. However, near mean high water, glasswort (*Salicornia* spp.) and sea lavender (*Limonium carolinianum*) become more common. Strong zonation also occurs in the higher parts, with zones of black needle rush (*Juncus roemerianus*) dominating. In the Project Area, smooth cordgrass is usually less than three feet in height. Soils of this community are mapped as Carteret sand and Bohicket silty clay loam. Both soil types are defined as nearly level, frequently flooded, and very poorly drained. These soils are normally found in tidal marshes on the sound side of the barrier islands less than 3 feet above sea level.

The nearest low marsh is 0 feet away from the inside of the permit perimeter on the east side of the Western Channel.

4.3.4 Submerged Aquatic Vegetation (SAV) Communities

Dominant, year-round seagrass species of North Carolina include both eelgrass (*Zostera marina*) and Cuban shoal grass (*Halodule wrightii*). Widgeon grass (*Ruppia maritime*) is otherwise commonly found growing in brackish water and low-saline pools of salt marshes. Seagrass species that dominate seasonally are *Z. marina* from winter to early summer, and *H. wrightii* from late summer through early fall. (Mallin et al, 2000)

Seagrass habitats are essential to sediment trapping and stabilization, nutrient uptake, and fishery habitats. These habitats also produce dissolved oxygen and assist in wave minimization, as well as supply detritus to the food chain. In addition to their photosynthetic properties, seagrass beds are also known to serve as a protective environment for the larval development of many marine species. Larval and juvenile stages of gag grouper (*Mycteroperca microlepis*), gray snapper (*Lutjanus griseus*), mullets *(Mugil* spp.), spot croaker (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonius undulates*), flounder (*Paralighthys* spp.), fish of the herring Family (Clupeidae) and others are frequently found in SAV (ASFMC, 1997). The bay scallop (*Argopecten irradians*) is an epibenthic, suspensionfeeding bivalve that is typically found inhabiting seagrass beds during both the juvenile and adult life stages. While the blue crab (*Callinectes sapidus*) and the pink shrimp (*Penaeus duorarum*), are also closely associated with seagrass habitat.

Seagrass habitats are characterized as Submerged Aquatic Vegetated (SAV) habitats, and the distribution and composition of seagrass communities are influenced by several factors; among the most important are light, salinity, wave action, and nutrient levels. Cowardin (1979) classifies SAV as an estuarine subtidal aquatic bed system which are most often found in the sheltered environments of shallow estuarine waters. High energy sand shoals are typically formed in the coastal bays and sounds of North Carolina and can be found in Bogue Inlet. These types of sand shoals are usually colonized by patchy seagrass colonies (Irlandi, 1998). Historically, seagrass beds around Bogue Inlet have been observed in areas behind Bear Island, around Dudley Island and throughout western Bogue Sound. USFWS (2002) stated that "the distribution of seagrasses with in Bogue Sound is estimated at over 6100 acres, consisting of a mix of widgeon grass, eelgrass, and shoalgrass."

In 1992, NOAA surveyed over 6,100 acres of SAV habitat in Bogue Sound. However, due to the time since NOAA's 1992 survey, the National Marine Fisheries Service requested that the Town of Emerald Isle conduct a pre-construction survey for SAV within the project area. Comparisons between NOAA's 1992 photo-interpreted seagrass map and June 30, 2003 digital imagery, combined with ground-truthing efforts conducted in late September 2003 showed that SAV or seagrass beds primarily were found in the high salinity areas of Bogue Sound generally in waters less than six feet in depth. The dominant seagrass species occurring within the Permit and Survey Area are eel grass (*Zostera maritima*) and shoal grass (*Halodule wrightii*). Dense seagrass beds are also found on the east side of Eastern Channel and Banks Channel. Scattered seagrass beds were identified north of Dudley Island and adjacent to Western Channel. The substrate type where SAV or seagrass